# OPTIMIZED ENDOSCOPIC REPAIR OF TRAUMATIZED FACIAL SKELETON: CRANIAL NERVE AUTOGRAFTING

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# OPTIMIZED ENDOSCOPIC REPAIR OF THE TRAUMATIZED FACIAL SKELETON: CRANIAL NERVE VII REGION

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# OPTIMIZED ENDOSCOPIC REPAIR OF THE TRAUMATIZED FACIAL SKELETON: CRANIAL NERVE VII REGION.

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The purpose of this study was to determine if a more optimal method of repairing facial fractures in the cranial nerve VII region could be achieved with the endoscope. Conservative management rarely achieves anatomic fracture repair and can result in irreversible structural deformity and dysfunction. Traditional operative methods require access through visible facial incisions and risk injury to the facial nerve. We report endoscopic methods of facial fracture repair that achieve excellent fracture reduction and stabilization, with minimal risk of facial nerve injury.

A consecutive series of 65 endoscopically assisted facial fracture repairs were analyzed. Endoscopic repairs of the condylar neck (n = 40) of the mandible were performed through an intraoral incision. Endoscopic arch repairs (n = 25) of the midface were performed through a preauricular incision. Outcomes were evaluated by postoperative fracture reduction on radiographs, occlusion, interincisal jaw opening, and facial nerve function.

Thirty-seven of 40 condylar neck mandible fractures went on to anatomic bone union, whereas 3 of 40 had either incomplete fracture reduction or re-fracture through the plate. There was one temporary palsy of CN VII that resolved spontaneously. Jaw opening exceeded 40 mm by the 8th postoperative week. Computed tomographic images demonstrated anatomic arch repair in all 25 endoscopically repaired cases. Six of seven endoscopically repaired Le Fort III facial fractures went on to restoration of their premorbid occlusion. One of seven had an excellent restoration of the occlusal interface but a cant to the occlusal plane. Two of seven had improved but incomplete restoration of the malar prominence and enopthalmos ipsilateral to the side of endoscopic arch repair. Eight of 25 endoscopic arch repairs developed temporary paralysis of the frontal branch of CN VII that recovered completely by the 10th postoperative week.

We have developed novel endoscopically assisted techniques to facilitate repair of facial fractures in the region of CN VII. These techniques have been successfully applied to accurately restore the facial skeleton to its preinjury anatomic position in the region of CN VII with minimal risk of facial paralysis by using limited and well-hidden incisions.

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## Introduction

The management of facial fractures has undergone many changes over the past 2 decades. Historically, the absence of powerful, accurate imaging tools delayed any sort of intervention until a proper external evaluation of facial contour, deformity, and function could be performed. In some instances, such as with orbital fractures, deformity might not even be apparent to external observation until several weeks after initial trauma. This delay in intervention often gave rise to technical difficulties with surgical repair because of early osseous union of malpositioned bone fragments and soft-tissue contracture. The advent of computed tomographic (CT) imaging provided physicians with an extraordinarily precise method to determine fracture malalignment of facial injuries. With this tool, fractures could be detected early and repaired immediately, even when physical examination was impaired by early facial swelling. [1]

Accurate CT imaging has facilitated strategic placement of aesthetically acceptable facial incisions to surgically expose, anatomically reduce, and place implants to rigidly stabilize the fracture until bone union takes place. Manson et al. [2–4] and Gruss et al. [5,6] popularized this single-staged rigid reconstruction of the aesthetic and functional components to the facial skeleton. This principle of open anatomic rigid internal fracture repair has gained wide acceptance and broad application over that of closed methods of fracture reduction and nonrigid bone stabilization, such as maxillomandibular fixation, external bandaging, and splinting. Despite these advances achieved from CT imaging, such as early fracture repair, treatment of the cranial nerve VII (CN VII) region of the facial skeleton remains the same as before CT imaging became available. Specifically, closed manipulations with external stabilization is still used commonly. [7]

Although open techniques of direct fracture repair have been broadly used by surgeons to anatomically reduce and rigidly fix most regions of the injured skull, the CN VII region of the facial skeleton has not been treated with this modern principle of fracture management. The CN VII region fractures, defined by injury of the condylar neck of the mandible and arch of the midface, are most commonly treated with closed manipulation and nonrigid stabilization. 7 Although it is accepted that anatomic restoration of displaced fracture fragments to their native position is the goal of facial fracture treatment, there remains a general reluctance to use open techniques to the CN VII region. This reluctance to expose the fracture stems from technical difficulty with placement of incisions to visualize the fracture and dissect around the facial nerve (Fig. 1). Accurate closed fracture repair is rarely achieved, and patients are forced to functionally adapt to the altered skeletal structures, resulting in higher likelihood of functional and aesthetic sequelae. 8,9 Silvennoinen et al. 10 have reported a 39% incidence of functional impairment after closed treatment of unilateral condylar neck fractures of the mandible. Only limited fractures of the CN VII region, with the most severe disruption, have justified extensive technically demanding operations. 6,11,12 For example, the coronal incision has been effectively used for open arch repair for complex zygomatic fractures and Le Fort III facial fractures (Fig. 1*A* and *B*). Although effective, such operations place the facial nerve, or its branches, at risk for transection and generally leave visible scarring.

This article details novel endoscopic methods for approaching this difficult CN VII region of the traumatized facial skeleton. The evolution of endoscopic fracture repair techniques, and our center's experience with 65 fractures will be described. Complications and pitfalls of treatments to the condylar neck mandible, complex

zygoma, and Le Fort III traumatic injuries will be explored along with the techniques necessary for optimal patient outcome.

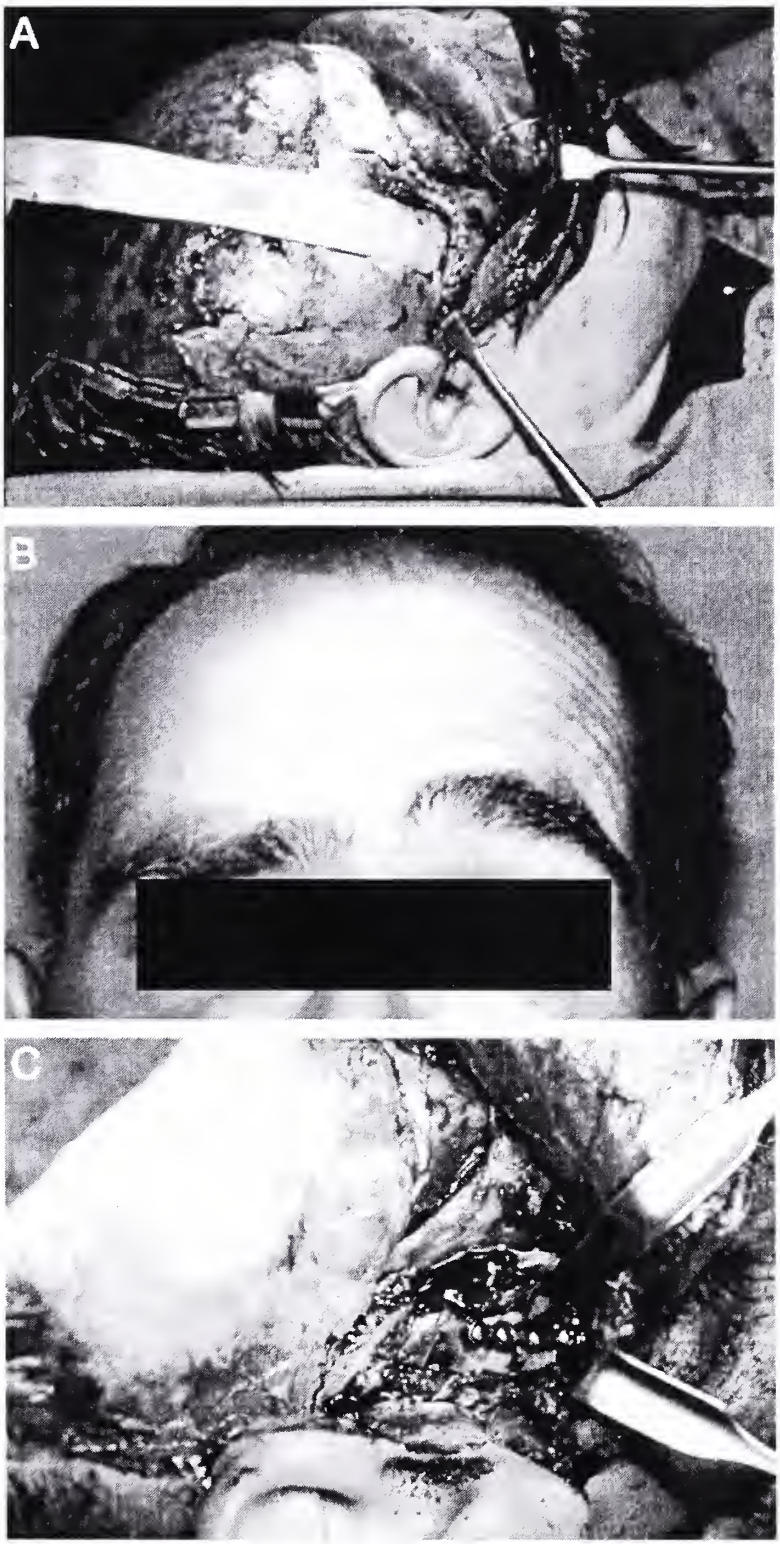

FIG 1. (*A*) Traditional open coronal incision requires extensive dissection to access the arch of the midface for repair. (*B*) There is risk of injury to the frontal branch of CN VII. (*C*) Open repair of the condyle is technically challenging, requiring both an extensive dissection and risks of transection of the main trunk of the facial nerve.

## MATERIALS AND METHODS

### Patients

Between the dates of August of 1995 and August of 1999, all patients with fractures of the CN VII region admitted to the Division of Plastic Surgery at the San Francisco General Hospital were evaluated with fine-cut axial and coronal computed tomographic (CT) images of the facial skeleton. All patients with radiographic findings of displaced fractures favorable to surgical intervention by endoscopically assisted fracture reduction and fixation were studied. To be considered for operative intervention, injuries had to demonstrate significant radiographic displacement or instability to clinical examination. Favorable criteria for endoscopic condylar neck repair in the mandible included mature adult mandible, noncomminuted and extracapsular injury with lateral override at the fracture site (Fig. 2*C* and *D*). 8,9 Criteria favorable for endoscopic midfacial arch repair included Le Fort III facial fractures not requiring cranial bone grafts, complex zygomatic fractures, comminuted isolated arch injuries not stable after closed reduction. 6,12–15 Pediatric patients were not entered in the study. All surgeries were performed by Chen Lee, MD. A retrospective compilation of patient data, including radiography and follow-up histories was prepared by Matthew Stiebel. Additionally, Matthew Stiebel assisted on three condylar neck mandible fractures included in the study group during July and August of 1999.

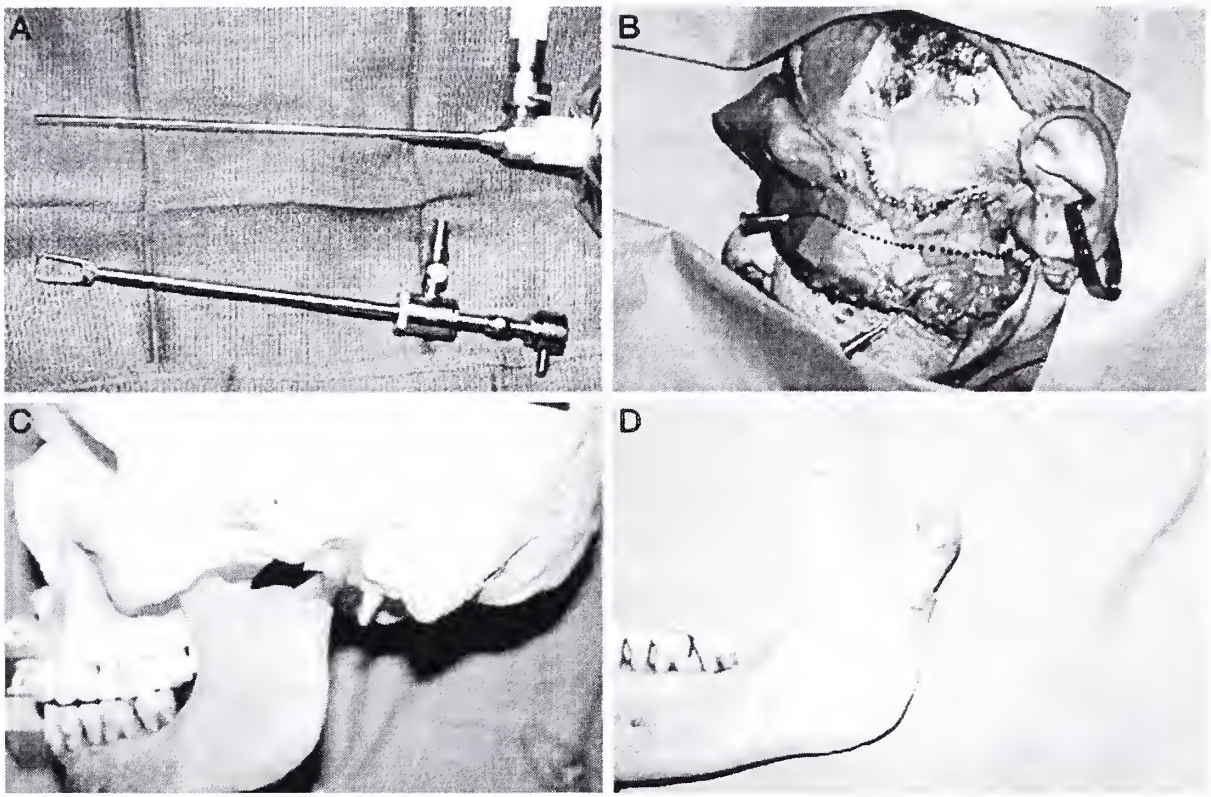


FIG 2. (*A*) The optical cavity is maintained by mechanical retraction of soft tissues. We have found the 4-mm endoscope-mounted retractor (Isse Dissector Retractor, Karl Storz, Tuttlingen, Germany) and 4-mm diameter, 30-degree angle scope (Karl Storz, Tuttlingen, Germany) especially useful for this purpose. (*B*) Cadaver dissection demonstrates the close proximity of CN VII to the condylar neck of the mandible and arch of the midface. (*C*) Condylar neck medial override fractures of the mandible are especially difficult to reduce because the ascending ramus of the mandible obscures the surgeon's access to manipulate the proximal fracture fragment. Usually, this is resolved by operatively converting the displacement into a more favorable lateral override before application of fixation. (*D*) The lateral override fracture alignment is favorable to endoscopic condylar neck repair.

## Endoscopic Equipment

Commercially designed equipment specific for the endoscopic repair of facial fractures does not yet exist. Most equipment used for this purpose has been adapted from endoscopic instrument sets designed for aesthetic soft-tissue surgery of the brow and face. Because the optical cavity is maintained by mechanical retraction of soft tissues, it is essential to have an endoscope-mounted retractor to simultaneously maintain the optical cavity and stabilize the orientation of the field. We have found the 4-mm endoscope-mounted retractor (Isse Dissector Retractor, Karl Storz, Tuttlingen, Germany)

especially useful for this purpose (Fig. 2*A*). The endoscope used was a 4-mm diameter, 30-degree angle scope (Karl Storz, Tuttlingen, Germany). Olympus Video System (Olympus America Inc., Lake Success, NY) composed of a three-chip camera, light source (Olympus XLS), camera converter (Olympus 3C-TV), and monitor (OEV 201) was used to project the endoscopic image to a video display.

## Endoscopic Surgical Technique

The vast majority of surgeons avoid open anatomic repair of mandibular condylar neck and midface arch fractures because of technical difficulties in fracture dissection in the vicinity of the CN VII (Fig. 2*B*). We sought to explore the possibility of remote access procedures to minimize the dissection CN VII challenges encountered with traditional open techniques. In June of 1995, eight fresh cadaver heads were dissected by Chen Lee, MD, to determine whether aesthetically acceptable remote access incisions and natural tissue planes could be used to create an internal optical cavity for fracture repair.

## Condylar Neck of the Mandible

This technique has been modified from that previously described. [8,9] The main trunk of CN VII lies directly over the neck of the mandibular condyle, whereas its more distal nerve divisions travel superficial to the parotid gland and masseter muscle. To safely create an optical cavity centered over the condylar neck, we found the dissections in our cadaver heads simplest with an intraoral buccal sulcus incision sited over the oblique line of the mandible. The optical cavity for endoscope placement was created by elevating the soft tissues in a subperiosteal plane from the entire lateral ramus of the mandible. Lateral

retraction of the optical cavity wall effectively retracted CN VII under the protective layers of the masseter muscle and parotid gland.

The optical cavity was maintained by transoral placement of the guarded endoscope-mounted retractor. Visibility of the proximal condylar segment was facilitated by rotation of the angled viewing surface of the endoscope toward the fracture. Fracture alignment can then be verified. The lateral override occurs in the majority of cases, whereas medial override fractures must be first manipulated into to lateral position before repair (Fig. 2*C* and *D*). Fracture reduction was facilitated by placing the patient into temporary maxillomandibular fixation. The proximal condylar segment can then be maneuvered into a reduced position by the end of a transbuccally placed trocar. Fixation screws are placed through the trocar.

## Arch of the Midface

This technique has been modified from that previously described. 13–15 Arch reduction and fixation enhances the accuracy and stability of zygomatic and midfacial fracture repair. Our cadaveric dissections have shown that it is possible to dissect out the entire midface arch through a preauricular incision at the anterior margin of the helical crus extending superiorly to approximately 2 cm above the auricle with low risk of transection to the frontal branch of the facial nerve (Fig. 2*B*). 14 To create an adequate optical cavity for endoscopic viewing, the scalp extension of the preauricular incision is used to expose the deep temporal fascia. An optical cavity is created superiorly by using a periosteal elevator to dissect superficial to the surface of the deep temporal fascia. Under optical endoscopic magnification, the dissection is carried in this plane down to the arch. To

prevent postoperative temporal hollowing, the temporal fat pad is not violated. The frontal branch of the facial nerve is not routinely visualized. Once the upper border of the arch is reached, the overlying periosteum is incised and the dissection is carried in a subperiosteal plane to expose the entire midfacial arch. Fracture reduction and fixation then proceeds by sequentially reducing and plating fractures with screws passed through a percutaneous trocar.

## Outcome Measurements

Early radiographic fracture reduction was evaluated by reviewing preoperative and postoperative CT images, whereas late bone union was followed with standard radiographs. Aesthetic changes were documented by standard lateral and anterior facial photographs by using a single photographic lens (focal length 105 mm) and film exposure. In patients with fractures potentially interfering with dental occlusion, such as Le Fort III and mandibular condylar injuries, jaw function was determined by documentation of occlusion and maximal interincisal jaw opening at follow-up. All patients were examined for facial nerve dysfunction.

## Statistical Analysis

Descriptive data analysis was performed. Measurements were reported as mean values with standard deviations.

## RESULTS

### Patient Profile

Sixty-five facial fractures of the CN VII region in 58 adult patients (6 women and 52 men) were found to be radiographically displaced and favorable to surgical intervention by endoscopically assisted fracture reduction and fixation. After the process of preoperative informed consent, all 58 patients elected to proceed with endoscopic fracture repair (Fig. 3*A*). The mean age of our patient population was 35.5 ± 8.3 years (range, 17–49 years). Average postoperative follow-up was 12 months (range, 5 weeks to 3 years) after the endoscopic intervention. The mean operative time for the endoscopic condylar neck portion of the mandible repair was 145 ± 50 minutes. The operative time required for upper facial injuries incorporating the endoscope for arch repair varied widely. It ranged from 1.7 hours for an isolated comminuted arch fracture to 14 hours for a panfacial fracture (Fig. 3*D*).

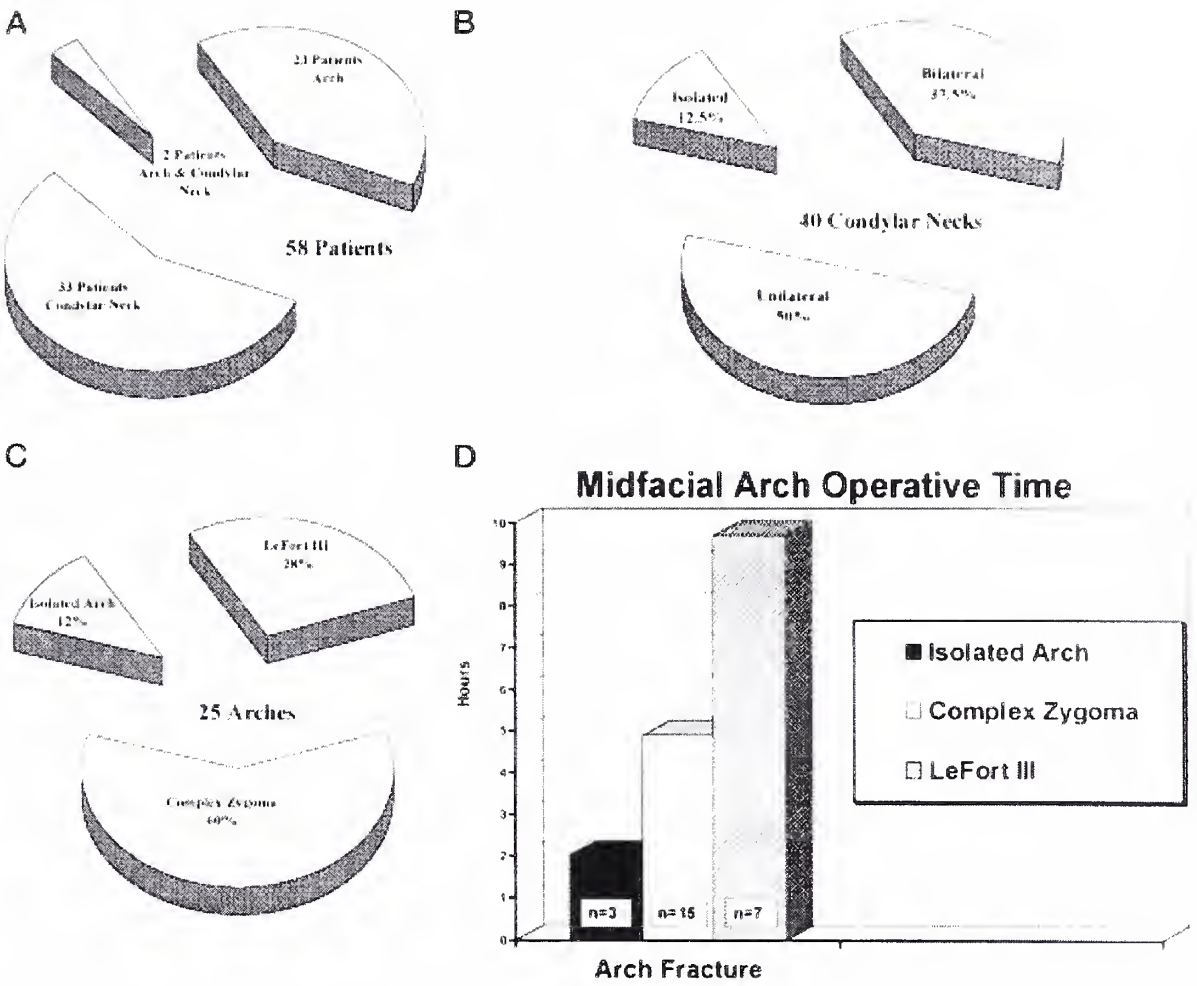


FIG 3. (*A*) Distribution of fractures in our patient population. (*B*) Most condylar neck fractures of the mandible treated with endoscopic repair also had concomitant open surgical repair at other sites of fracture within the mandible. (*C*) In the majority of cases, midfacial endoscopic arch repair was performed as a single component of a more complex repair. (*D*) The mean operative time necessary to repair arch-related fractures of the midface correlated well with the complexity of the facial injury.

## Condylar Neck Repair

A total of 45 condylar neck fractures were identified. Five of 45 fractures were excluded from operative repair because of radiographic evidence of comminution and intracapsular location. The remaining 40 condylar neck fractures were treated with endoscopically assisted reduction and rigid plate fixation (Fig. 3*B*). Thirty-six of these 40 treated condylar neck fractures demonstrated lateral override or transverse positioning of the proximal condylar segment over the native lateral ramus (Fig. 4*C*). The other four treated condylar

neck fractures presented with medial override of the proximal condylar segment over the native lateral ramus. Five condylar neck fractures had some degree of medial subluxation of the condylar head in relation to the fossa, whereas three fractures had complete anteromedial dislocation of the condylar head out of the fossa. In 2 of the 40 fractures repaired by using the endoscopic method, fracture reduction was achieved but internal fixation was aborted because bone comminution and high fracture positions on the condylar neck precluded placement of fixation plates. Instead, maxillomandibular fixation was used. Although endoscopic fracture reduction was achieved, the lack of internal fixation resulted in loss of the reduction in one patient despite a 4-week postoperative course of maxillomandibular fixation. In 38 of 40 fractures, anatomic fracture reduction and rigid internal plate fixation was achieved and confirmed on early postoperative CT images. Thirty-seven internally fixed fractures went on to near anatomic fracture union without postoperative maxillomandibular fixation (Fig. 4). One of 38 patients presented with a late re-fracture through the plate. Thirty-seven of 40 patients went on to functional recovery with all patients exceeding 40 mm of interincisal jaw opening by the 8th postoperative week without the discomfort of maxillomandibular fixation.

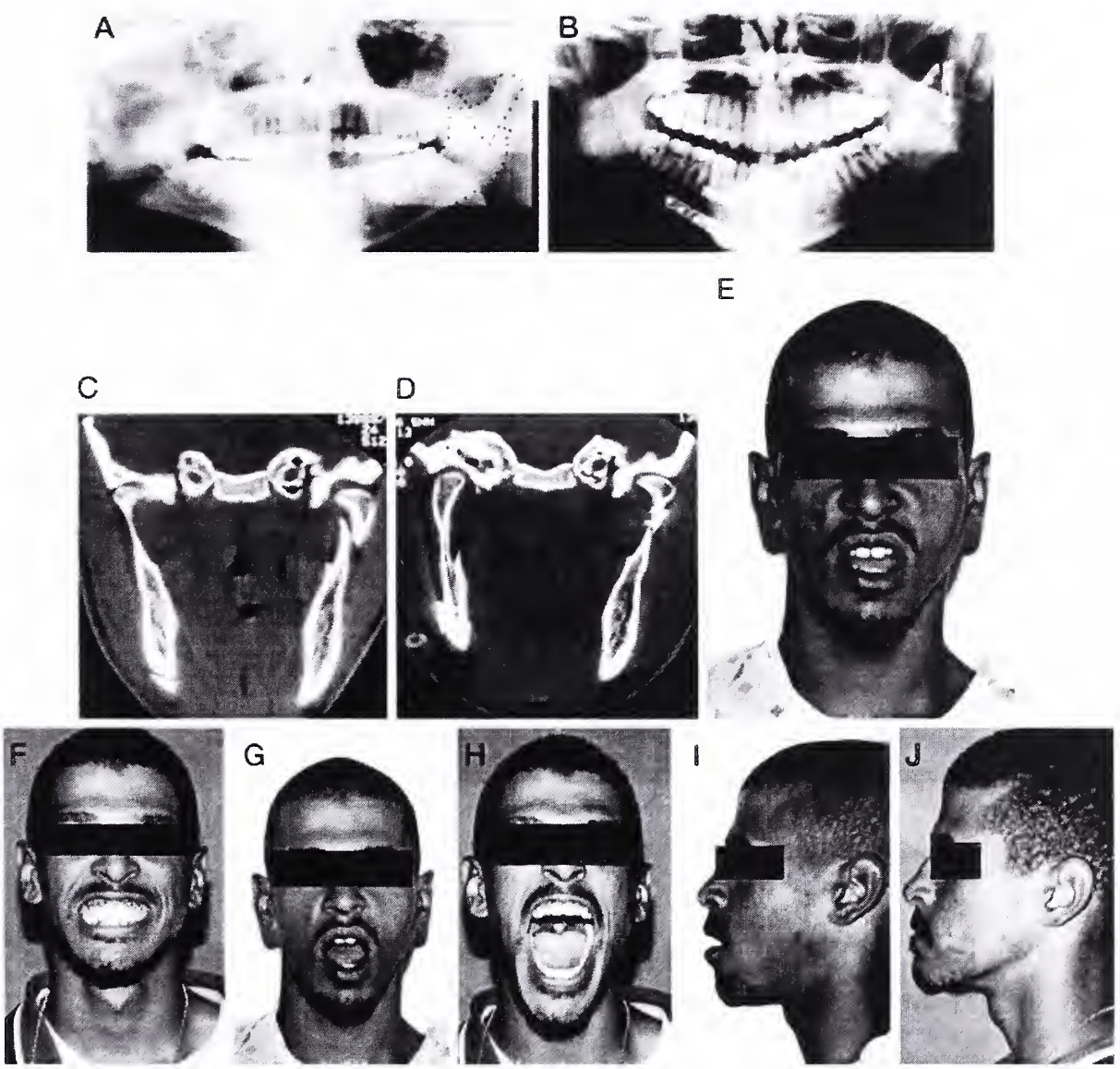


FIG 4. (*A*) Preoperative Panorex showing a left condylar neck fracture. The posterior mandibular height was shortened, and the proximal condylar segment was flexed. (*B*) Postoperative Panorex demonstrates correction of the flexed position of the proximal condylar fragment. (*C*) Preoperative coronal computed tomography demonstrated an extracapsular fracture with lateral override and shortening of the posterior mandibular height. The length of the extracapsular proximal fracture fragment was found to be sufficient to anchor proximal plate fixation screws. (*D*) After endoscopic repair, anatomic correction of the fracture was confirmed on the radiographs. The posterior mandibular height has been restored. (*E*) Preoperative frontal view with patient attempting to bring teeth into occlusion. (*F*) Postoperative occlusion. Preoperative restriction in jaw opening (*G*) restored after endoscopic repair (*H*). (*I*) Preoperative lateral facial view shows loss of chin projection in this patient with left mandibular condylar neck fracture. (*J*) Postoperative chin point and jaw line restored after left endoscopic condylar neck repair without postoperative maxillomandibular fixation.

## Arch Repair

Twenty-five fractures of the midfacial arch were repaired endoscopically (Fig. 3*C*). Two of these patients also had an associated condylar neck fracture repaired by endoscopic assistance. Seven patients had an endoscopic arch repair as part of the Le Fort III midfacial fracture repair, whereas 15 patients had an arch repair as part of a complex zygomatic fracture repair. Three patients had an isolated arch fracture.

All 25 patients had good aesthetic results after endoscopic arch repair. CT images were used to determine the accuracy of the repair. All three isolated arch fractures were anatomically repaired. All 15 endoscopically repaired complex zygomatic injuries went on to anatomic fracture reduction as confirmed on postoperative CT images (Fig. 5). All seven endoscopically repaired Le Fort III facial fractures had anatomic reduction of the arch on postoperative CT images. Clinically, six of seven Le Fort III facial fractures went on to restoration of their premorbid occlusion (Fig. 6). The remaining patient had an excellent restoration of the occlusal interface but a cant to the occlusal plane. Two of the seven had improved but incomplete restoration of the malar prominence and enopthalmos ipsilateral to the side of endoscopic arch repair.

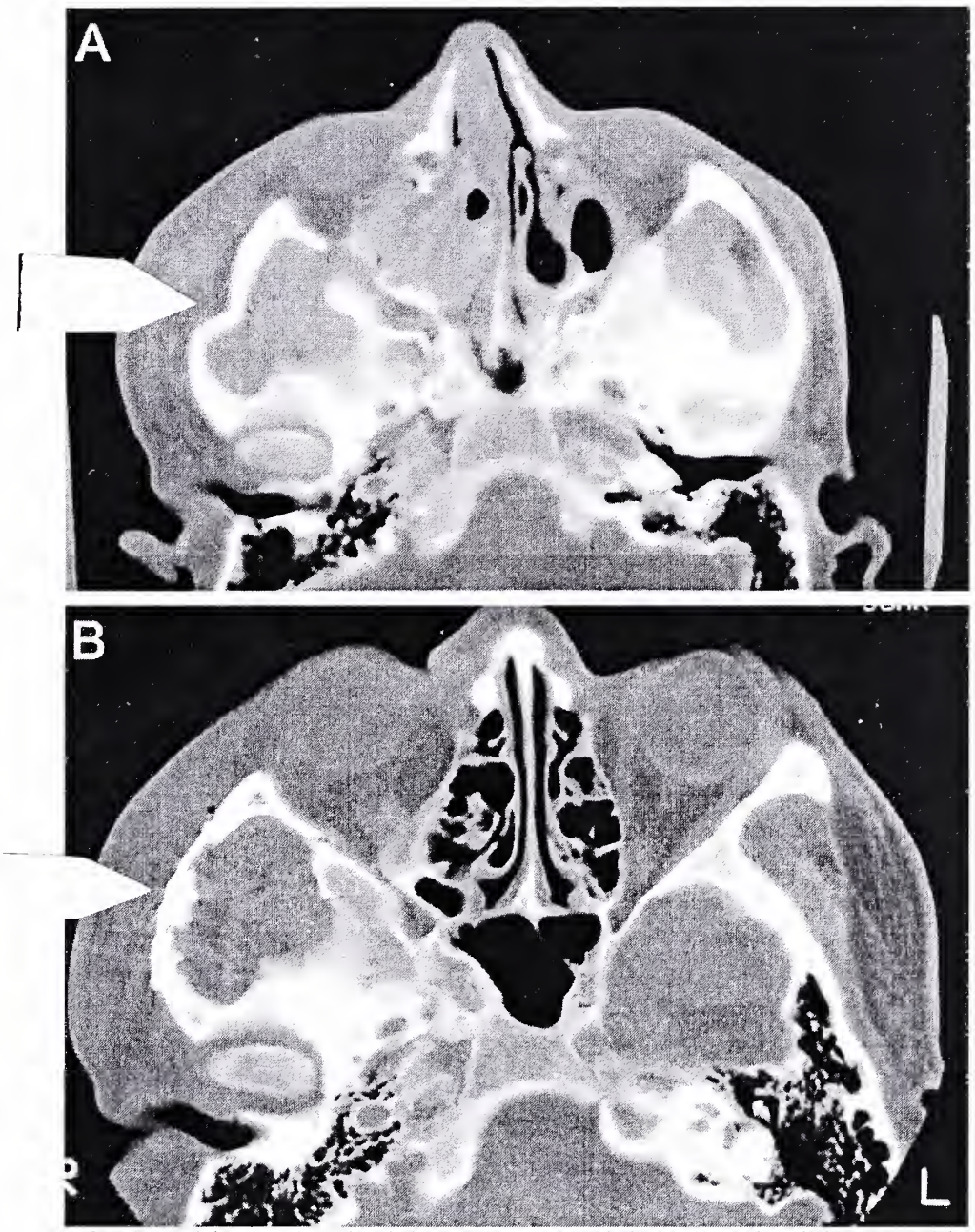


FIG 5. (*A*) A right comminuted arch fracture is present with depression and medial rotation of the zygoma. (*B*) The arch fracture and zygomatic position are anatomically and rigidly restored with an endoscopic repair.

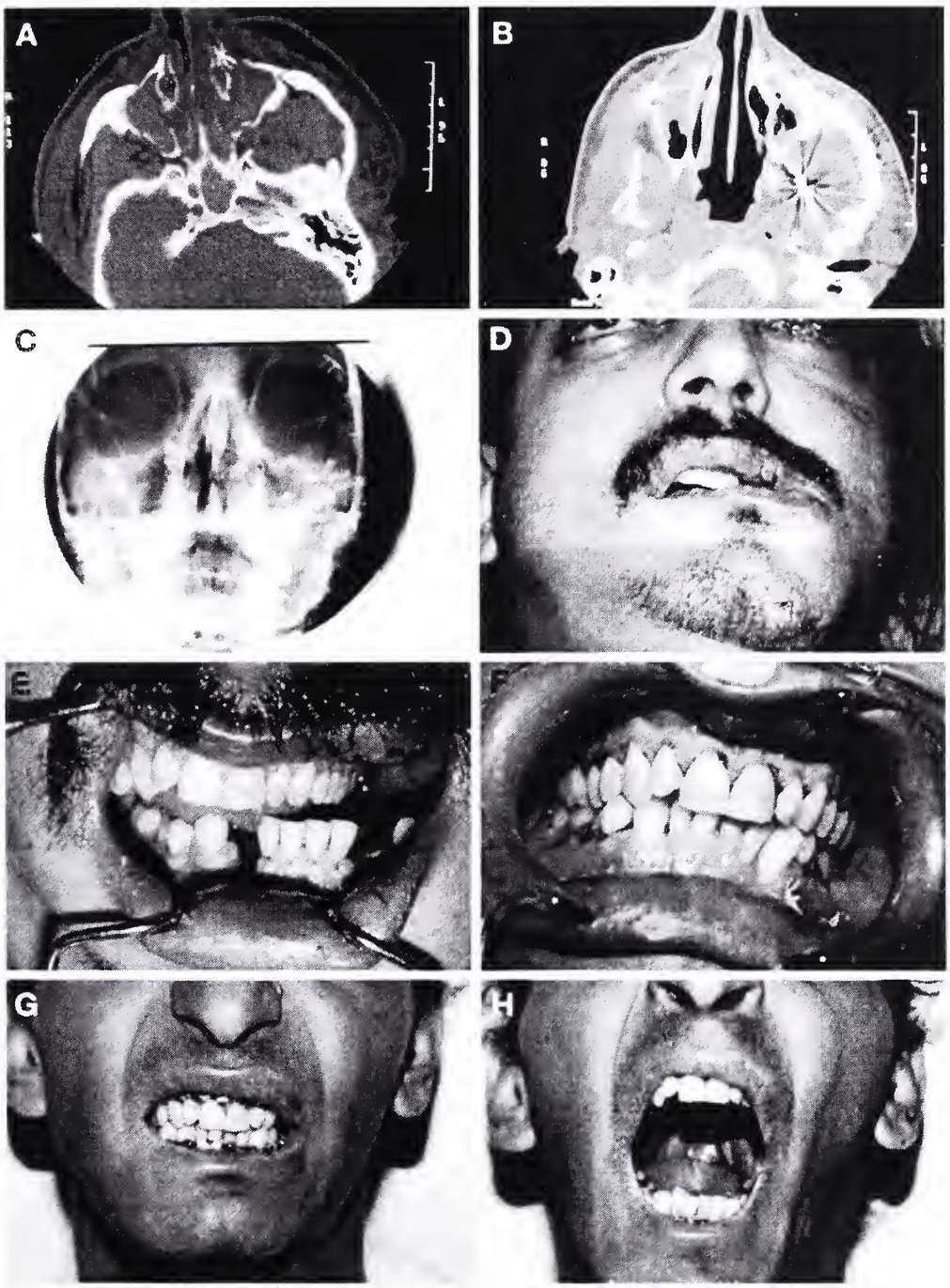


FIG 6. (*A*) Complex panfacial fracture with left-sided Le Fort III component to the fracture is present on CT imaging. (*B*) Endoscopic reduction and rigid internal stabilization forms the foundation on which to build the facial reconstruction. (*C*) Stability of the left facial reconstruction relies on the rigid endoscopically repaired arch. (*D*) Preoperative midfacial instability is present. (*E*) Malocclusion results from both midfacial and mandibular injuries. (*F*) Accurate midfacial repair is essential, in that it becomes the template by which the mandible is restored. (*G* and *H*) Four weeks after surgery, the patient had a stable occlusion and excellent jaw function.

## Facial Nerve Paralysis

No permanent CN VII injuries occurred in our series of 65 endoscopic facial fracture repairs. One of 40 endoscopic condylar neck fracture repairs resulted in temporary traction palsy of the facial nerve after aggressive retraction of soft tissues. The facial nerve palsy resolved spontaneously and completely. Eight of 25 endoscopic midfacial arch repairs had temporary paralysis of the frontal branch of CN VII. These palsies were found in 4 of 7 Le Fort III, 3 of 15 complex zygoma, and 1 of 3 isolated arch endoscopic midfacial repairs. CN VII palsies were likely caused by traction injury and all proceeded to spontaneous and complete recovery by the 10th postoperative week.

## DISCUSSION

Better patient outcomes justify the use of the endoscope in surgery. For universal acceptance, surgery with the endoscope must be cost effective, quicker than standard techniques, and decrease patient morbidity. It was only after extensive product development and ample training periods that such goals were realized. As a testament to its acceptance, competence with the endoscope has become a requirement for anyone today training in the field of general surgery.

Plastic surgeons are at the same threshold that pioneering general surgeons faced when they initially brought the endoscope into the operating room. Just as with the laparoscopic surgeons before us, we need to justify the benefits an endoscope would bring to our existing surgical armamentarium. Additionally, we are in the exciting position to have the opportunity to use the endoscope on injuries that were previously not treated with surgery. We hope to convince the reader that the endoscopic repair of facial fractures is a better method to treat these injuries.

By far, the greatest improvement offered by the endoscope is decreased patient morbidity. At present, the vast majority of mandibular condylar neck fractures are treated with conservative closed reduction by using maxillomandibular fixation (MMF). MMF involves wiring the occlusal interface of the maxilla to the mandible for up to for 4 weeks with the intent of using the dentition to align the fracture. However, MMF rarely, if ever, produces accurate anatomic fracture reduction. Emphasis is then placed on rehabilitation and long-term forced adaptation to altered condylar mechanics. The incidence of functional mandibular derangements after MMF treatment of isolated unilateral condylar

neck fractures has been as high as 39%. [10] Furthermore, as a result of this malunion, the shortened posterior mandible leads to dynamic alterations in aesthetic jaw movements in almost all patients treated with MMF. [8] Attempts to improve functional and aesthetic outcomes for patients with condylar neck injuries led to complicated open surgical procedures (Fig. 1*C*). [16–18] Although these operations typically produced good reductions, the difficulty in fracture exposure demanded extraordinarily skilled surgeons who were willing to use highly visible facial incisions and risk facial nerve transection. Our use of the endoscope mitigates some of these pitfalls. The ability to increase visibility and simultaneously make smaller, hidden incisions makes the endoscope attractive for work in such delicate areas. With endoscopic technology, we have anatomically repaired 37 displaced condylar neck fractures, restored normal condylar mechanics and the aesthetic jawline without the discomfort of prolonged MMF or visible facial scarring.

Currently, the endoscope is not yet a perfect solution to condylar neck injuries. Operative time for endoscopic procedures is approximately 2.5 hours and more time consuming than MMF. When compared with conservative closed management with MMF, we believe the increased operative time is worth the improved fracture alignment, long-term efficiency of restored mechanical function, and decreased duration of postoperative rehabilitation. Although there is a risk of temporary facial nerve palsy, the likelihood of nerve transection is greatly reduced compared with traditional open surgical methods of fracture repair. As with other endoscopic specialties, the development of design-specific endoscopic instrumentation for facial fracture repair should shorten operative time in the future.

Fractures to the arch of the midface have also benefited from endoscopic intervention. [13–15] The proximity of the frontal branch of CN VII over the middle segment of the arch makes fractures difficult to approach surgically. Traditional access has necessitated an extended coronal incision requiring extensive dissection with increased blood loss, scarring, and scalp alopecia (Fig. 1*A* and *B*). [6,12] With the endoscope, the extent of dissection, blood loss, and scarring is drastically reduced. It has been effective in managing a broad range of injuries, including Le Fort III, complex zygomatic, and isolated arch fractures, with better short-term morbidity. Just as with the endoscopic condylar neck repairs, traction facial nerve palsies are a risk, but no permanent nerve injuries were seen.

To conclude, our experience with endoscopic repair of the CN VII region of the facial skeleton has provided patients with less postoperative morbidity. Compared with closed reduction, the most broadly used intervention for these injuries, operative time required to complete endoscopic fracture repair is greater. However, we believe this increased expenditure of operative time is justified to achieve anatomic fracture repair, which is the hallmark of treatment for the vast majority of all other fractures. With regard to operative time, we believe a comparison to traditional open surgical approaches is more appropriate and would likely be favorable for the endoscopic methods. However, such a comparison is difficult because most surgeons avoid traditional open methods because of the technical difficulties in dissection about the CN VII. Another issue is cost effectiveness. We presume that the decreased patient morbidity should translate into reduced reoperation for malunited facial bones and lessen the need for rehabilitation, but additional studies are needed to address this issue.

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